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A SUMMARY OF WATERBORNE ILLNESS TRANSMITTED THROUGH CONTAMINATED GROUNDWATER

by

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16. ABSTRACT

The use of contaminated, untreated or inadequately treated groundwater was responsible for 51 percent of all waterborne outbreaks and 40 percent of all waterborne illness reported in the United States during the period 1971-82. Contaminated, untreated or inadequately disinfected groundwater caused 65 percent of the waterborne outbreaks and 66 percent of the waterborne illness which occurred in noncommunity and individual water systems but only 32 percent of the outbreaks and 31 percent of illness in community water systems. Illnesses most frequently transmitted through groundwater included acute gastroenteritis of undetermined etiology, chemical poisonings, hepatitis A, shigellosis, and viral gastroenteritis. Waterborne outbreaks in water systems using untreated well water were caused primarily by the overflow or seepage of sewage from septic tanks or cesspools, chemical contamination, and surface runoff contamination. An increase in the number of outbreaks resulting from the use of untreated, contaminated groundwater was noted during the summer months.

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Abstract

The use of contaminated, untreated or inadequately treated groundwater was responsible for 51 percent of all waterborne outbreaks and 40 percent of all waterborne illness reported in the United States during the period 1971-82. Contaminated, untreated or inadequately disinfected groundwater caused 65 percent of the waterborne outbreaks and 66 percent of the waterborne illness which occurred in noncommunity and individual water systems but only 32 percent of the outbreaks and 31 percent of illness in community water systems. Illnesses most frequently transmitted through groundwater included acute gastroenteritis of undetermined etiology, chemical poisonings, hepatitis A, shigellosis, and viral gastroenteritis. Waterborne outbreaks in water systems using untreated well water were caused primarily by the overflow or seepage of sewage from septic tanks or cesspools, chemical contamination, and surface runoff contamination. An increase in the number of outbreaks resulting from the use of untreated, contaminated groundwater was noted during the summer months.

Introduction

The U.S. Environmental Protection Agency (EPA), Cincinnati, Ohio, and the Centers for Disease Control (CDC), Atlanta, Georgia, cooperate in the investigation and reporting of waterborne disease outbreaks in the United States. As part of this reporting system, state epidemiologists and engineers in state water supply surveillance agencies have provided data on waterborne outbreaks to EPA and CDC annually since 1971. This report summarizes the data available on the occurrence of waterborne disease outbreaks in the United States during 1971-82, emphasizing outbreaks caused by the consumption of contaminated groundwater.

The waterborne outbreaks reported are those in which drinking water was epidemiologically implicated as the vehicle of transmission of the illness. In most of the outbreaks drinking water was found to be bacteriologically or chemically contaminated, but only in a few of the outbreaks was the etiologic agent isolated from drinking water. Included are outbreaks associated with water used or intended for drinking or domestic purposes and outbreaks associated with the use of contaminated springs and creeks by backpackers and campers.

For purposes of analysis, the water systems were classified as community, noncommunity, and individual according to definitions contained in the Safe Drinking Water Act (P.L. 93-523). Community water systems are public or investor-owned water supplies serving large or small communities, subdivisions, or trailer parks having at least 25 year-round residents or 15 service connections used by year-round residents. Noncommunity water systems must regularly serve an average of at least 25 individuals for 60 or more days out of the year. These systems serve primarily transients and include institutions, industries, camps, parks, hotels, and service stations which have their own water supply available for use by employees and the general public. Individual water systems are used by residents in areas without community systems or by persons traveling outside of populated areas (e.g., backpackers, campers).

Occurrence and Distribution of Outbreaks

Three hundred and ninety-nine waterborne outbreaks and 86,050 cases of waterborne disease were reported during 1971-82; three deaths were associated with these outbreaks (Table 1). Most of the outbreaks (48 percent) occurred

in noncommunity water systems, but most cases of illness (75 percent) resulted from outbreaks in community water systems, which are generally larger and serve more people than noncommunity water systems (Table 2). Based on current estimates of population served, the incidence of waterborne illness was larger in noncommunity systems (8.8 cases per 100,000 person-yrs.) than in community systems (3.0 cases per 100,000 person-yrs).

Two hundred and four outbreaks (51 percent) and 34,337 cases of illness (40 percent) were caused by contaminated groundwater which was either not disinfected or inadequately disinfected (Table 3). The use of contaminated, untreated groundwater was responsible for 31 percent of all waterborne outbreaks and 11 percent of all waterborne illness, and the use of inadequately disinfected groundwater was responsible for an additional 20 percent of the outbreaks and 29 percent of the cases of illness. Most of these outbreaks (177) and illnesses (30,046) occurred in systems using well water; only 27 of these outbreaks and 4291 cases of illness occurred in systems using springs.

The use of untreated, contaminated groundwater was responsible for 105 outbreaks and 8369 cases of illness in noncommunity and individual water systems and 20 outbreaks and 1457 cases of illness in community water systems (Table 4). The use of inadequately disinfected groundwater was responsible for 49 outbreaks and 5867 cases of illness in noncommunity water systems and 30 outbreaks and 18,644 cases of illness in community water systems (Table 4). Untreated, contaminated groundwater caused 44 percent of the waterborne outbreaks and 39 percent of the waterborne illness which occurred in noncommunity and individual water systems but only 13 percent of the outbreaks and 2 percent of the illness in community water systems. Noncommunity and indivi-

dual water systems can generally obtain adequate quantities of water from groundwater sources to meet consumption requirements and often use groundwater sources without treatment. It is, therefore, not surprising that untreated, contaminated groundwater is a major cause of the outbreaks and illnesses which occur in these water systems. The importance of untreated, contaminated groundwater as a cause of outbreaks in noncommunity and individual water systems during 1971-82 is similar to that observed during 1946-70.[1] Most small community water systems also use groundwater sources, but with increasing consumption requirements of large populations and industry, many larger communities can provide adequate quantities of water only by using surface water sources. Approximately one-third of the population served by community water systems is provided water solely from groundwater sources, and most of these individuals receive treated groundwater.[2] Outbreaks in community water systems which were caused by untreated, contaminated groundwater generally occurred in small water systems and resulted in few cases of illness. During 1946-70, larger community water systems using untreated groundwater experienced outbreaks, and untreated, contaminated groundwater caused 41 percent of the illnesses which occurred in community water systems.[1] Inadequately disinfected groundwater caused 21 percent of the waterborne outbreaks and 27 percent of the waterborne illness which ocurred in noncommunity and individual water systems and 19 percent of the outbreaks and 29 percent of the illness in community water systems. Inadequately disinfected groundwater caused a much smaller proportion of outbreaks and illnesses in all water systems during 1946-70.[1] Increasing contamination of groundwater sources may be responsible for these outbreaks, and systems with marginal disinfection may not be able to cope with this increased contamination. Some groundwaters are disinfected only to provide a chlorine residual throughout the distribution

system, and intermittent contammination of the source frequently overwhelms the disinfection provided for this purpose.

A seasonal distribution of outbreaks in well water systems is apparent. Over half of the outbreaks caused by contaminated, untreated and inadequately disinfected well water occurred during the months of June, July, and August (Figures 1 and 2). Too few outbreaks occurred in systems using springs to detect a seasonal variation. Outbreaks in groundwater systems primarily occurred among visitors rather than usual residents served by the water systems; 60 percent of the outbreaks caused by untreated, contaminated groundwater and 63 percent of those caused by inadequately, disinfected groundwater effected visitors (Table 5). Travelers, campers, restaurant patrons, and visitors to recreational areas were among the groups most frequently involved. Because these outbreaks occur primarily among visitors, it is difficult to ascertain whether the seasonal distribution is a result of increased contamination of groundwater during the summer or due to an increased number of susceptible individuals using groundwater supplies which are always contaminated.

Etiologic Agents

An etiologic agent was determined in 48 percent of all reported waterborne outbreaks (Table 6). The remaining outbreaks were categorized as acute gastrointestinal illness characterized by symptoms including abdominal cramps, nausea, vomiting, and diarrhea occurring 12 to 48 hours after consumption of the water. The most commonly identified pathogen was Giardia lamblia, a flagellated protozoan responsible for giardiasis. Sixty-four waterborne outbreaks of giardiasis, representing 16 percent of the reported waterborne

outbreaks, occurred during 1971-82. Although waterborne outbreaks of giardiasis occurred primarily in surface water systems with no treatment or disinfection as the only treatment (Table 7), four outbreaks of giardiasis were caused by contaminated, untreated and inadequately treated springs (Table 8) and three outbreaks of giardiasis were caused by contamination of untreated well water (Table 9). Forty-five (11 percent) outbreaks of chemical poisoning, 28 (7 percent) outbreaks of shigellosis, 19 (5 percent) outbreaks of hepatitis A, and 15 (4 percent) outbreaks of viral gastroenteritis were reported.

An etiologic agent was identified in only 39 percent of the outbreaks caused by contaminated, untreated groundwater (Tables 8 and 9). Twelve of the outbreaks in untreated groundwater systems were caused by chemical contamination including petroleum products (lubricating oil, fuel oil, gasoline), nitrate, polychlorinated biphenyls, trichloroethylene, phenols, benzene, arsenic, and selenium, but these outbreaks resulted in only 157 cases of illness. Not included were an additional six outbreaks of acute fluoride poisoning caused by improperly designed or malfunctioning equipment and operational problems in the addition of fluoride to well waters; five of these outbreaks occurred at elementary schools. Fifteen of the outbreaks in untreated groundwater systems were caused by viral agents (hepatitis A and Norwalk-like agent), and twelve were caused by shigella. An etiologic agent was identified in only 29 percent of the outbreaks caused by inadequate or interrupted disinfection of groundwater (Tables 8 and 9). Eight of these outbreaks were caused by shigella, and eight were caused by viral agents (hepatitis A and Norwalk-like agent).

Causes of Outbreaks

The major cause of waterborne outbreaks and waterborne illness for all types of water systems during this twelve-year period was no treatment or inadequate treatment for various water sources (Figures 3 and 4).

Use of contaminated, untreated well water was responsible for 28 percent of all outbreaks and 10 percent of all cases of illness. One hundred and ten outbreaks occurred in well water systems used without treatment (Table 10). Overflow or seepage of sewage, primarily from septic tanks or cesspools, was responsible for 43 percent of the outbreaks caused by use of contaminated, untreated well water. This includes outbreaks where contaminants travelled through limestone or fissured rock. Eleven percent of the outbreaks in untreated well water systems were caused by chemical contamination, and surface runoff contamination caused nine percent of these outbreaks. Insufficient data were available to establish a source of contamination for 35 percent of the outbreaks in untreated well water systems, emphasizing the need for better engineering investigations if contamination problems for untreated groundwater sources are to be understood.

A few communities, individuals, and establishments still use surface water and spring water without treatment, and outbreaks continue to be caused by use of contaminated, untreated surface water (8 percent) and spring water (4 percent). However, insufficient data were available to establish the source of contamination in most of these outbreaks. Outbreaks in water systems using untreated water from springs occurred primarily because springs were contaminated by surface runoff.

Since the microbiological quality of groundwater is usually good, disinfection is generally provided to protect against possible contamination of the distribution system, and this minimal disinfection may be inadequate to deal with an unexpected contamination of the source. Some groundwater systems must use a source which is frequently or intermittently contaminated, and outbreaks are caused by inadequate disinfection of the contaminated source water and interrupted disinfection due to equipment malfunction or an insufficient supply of the disinfectant. Inadequate or interrupted disinfection of well water was responsible for 17 percent of all outbreaks and 25 percent of the cases of illness. Most of these outbreaks were associated with the use of chlorine for disinfection, but four outbreaks in well water systems were caused by inadequate or interrupted disinfection by iodine. These occurred in small noncommunity systems serving primarily a transient population. Inadequate or interrupted disinfection of spring water was responsible for 3 percent of the outbreaks and 4 percent of the cases of illness.

Most of the waterborne outbreaks and cases of illness caused by distribution system deficiencies were due to cross-connections, backsiphonage, and contamination of distribution storage (Table 11), and almost all of these occurred in community systems. Miscellaneous deficiencies responsible for waterborne outbreaks included use of water not intended for drinking, ingestion of contaminated water while swimming, contaminated ice, and deliberate contamination (Table 12).

Conclusions

Waterborne outbreaks continue to occur in the United States, and a

significant number of outbreaks and cases of disease occur because of groundwater contamination and the inadequate treatment of groundwater. It is suspected that sources are subject to increasing contamination. Groundwater sources are generally used by smaller communities, individuals, and establishments frequented by visitors, and the outbreak data indicate that these systems, some of which may be used on a seasonal basis, are showing the strains of an increasing demand placed upon them by large numbers of visitors. Additional surveillance is necessary to prevent outbreaks from occurring, especially in small community water systems and noncommunity water systems. Emphasis must be placed on sanitary surveys: to determine the quality of the groundwater and identify possible sources of contamination; to ensure that wells and springs are adequately developed and protected from surface water runoff and other sources of contamination, such as overflow and seepage from septic tanks, to recommend adequate treatment when required, and to provide for the proper operation of these systems so that continuous, effective disinfection will be maintained for groundwater sources which are known or suspected to be intermittently or continuously contaminated.

References

1. Craun, G.F. and McCabe, L.J., Review of the Causes of Waterborne-Disease Outbreaks, Journal American Water Works Association, 65, 74, 1973.
2. Jenkins, K.H., Statistical Summary of Municipal Water Facilities in the United States, Jan. 1, 1963, Public Health Service Publication No. 1039, Washington, D.C., 1965.

TABLE 1

Waterborne Outbreaks in the United States
1971-82

Year	Outbreaks	Cases of Illness
1971	20	5,184
1972	30	1,650
1973	25	1,762
1974	25	8,356
1975	24	10,879
1976	35	5,068
1977	34	3,860
1978	32	11,435
1979	42	9,750
1980	53	20,045
1981	35	4,450
1982	44	3,611

TABLE 2

Waterborne Outbreaks by Type of Water System
1971-82

Water System	Outbreaks	Cases of Illness
Community	160	64,406
Noncommunity	190	21,002
Individual	49	642
	399	86,050

TABLE 3

Waterborne Outbreaks in Groundwater Systems
1971-82

Water System	Outbreaks		Cases of Illness	
	Wells	Springs	Wells	Springs
1. Untreated Groundwater				
A. Community	15	5	1,334	123
B. Noncommunity	73	8	7,029	1,116
C. Individual	22	2	195	29
Subtotal	110	15	8,558	1,268
2. Inadequately Disinfected Groundwater				
A. Community	26	4	17,125	1,519
B. Noncommunity	41	8	4,363	1,504
C. Individual	0	0	0	0
Subtotal	67	12	21,488	3,023
Totals	117	27	30,046	4,291

TABLE 4

Causes of Groundwater Outbreaks by Type of Water System

Causes of Outbreaks	Outbreaks		Cases of Illness	
	Community Systems	Other Systems	Community Systems	Other Systems
Untreated Groundwater	20(13%)	105(44%)	1,457(2%)	8,369(39%)
Inadequately Disinfected Groundwater	30(19%)	49(21%)	18,644(29%)	5,867(27%)
Other Causes	110(68%)	85(35%)	44,305(69%)	7,408(34%)
All Causes	160(100%)	239(100%)	64,406(100%)	21,644(100%)

TABLE 5

Groundwater Outbreaks Effecting Visitors
1971-82

Water System	Untreated Groundwater		Inadequately Groundwater	
	Wells	Springs	Wells	Springs
Motel, hotel, camp, park, resort	41	5	21	7
Restaurant, country club	16	1	17	0
School, day-care center, church	6	0	3	1
Factory, office, store	5	1	1	0
	68	7	42	8

TABLE 6

Etiology of All Waterborne Outbreaks
1971-82

Etiologic Agent	Number of Outbreaks	Percent of Outbreaks
Unknown	209	52
Giardia	64	16
Chemicals	45	11
Shigella	28	7
Hepatitis A	19	5
Norwalk Agent, Rotavirus	15	4
Salmonella	8	2
S. Typhi	4	1
Campylobacter	4	1
Toxigenic E. coli	1	<1
Yersinia	1	<1
Cholera	1	<1
Totals	399	100

TABLE 7

Etiology of Waterborne Outbreaks in Untreated or Disinfected Only Surface Water Systems 1971-82

Illness	Outbreaks	Cases
1. Untreated Surface Water		
A. Gastroenteritis	14	1,006
B. Giardiasis	12	351
C. Shigellosis	2	278
D. Campylobacterosis	1	21
E. Hepatitis A	1	17
F. Salmonellosis	1	3
Subtotal	31	1,676
2. Inadequate or Interrupted Disinfection of Surface Water		
A. Giardiasis	31	10,742
B. Gastroenteritis	20	7,159
C. Viral Gastroenteritis	3	1,976
D. Camplyobacterosis	1	3,000
E. Shigellosis	1	50
F. Salmonellosis	1	34
Subtotal	57	22,961
Totals	88	24,637

TABLE 8

Etiology of Waterborne Outbreaks in Untreated or Disinfected Only Groundwater (Springs) Water Systems 1971-82

Illness	Outbreaks	Cases
1. Untreated Spring Water		
A. Gastroenteritis	7	1,052
B. Hepatitis A	4	114
C. Shigellosis	2	58
D. Giardiasis	2	44
Subtotal	15	1,268
2. Inadequate or Interrupted Disinfection of Spring Water		
A. Gastroenteritis	7	1,444
B. Giardiasis	2	29
C. Toxigenic *E. Coli* AGI	1	1,000
D. Viral Gastroenteritis	1	500
E. Hepatitis A	1	50
Subtotal	12	3,023
Totals	27	4,291

TABLE 9

Etiology of Waterborne Outbreaks in Untreated or Disinfected Only Groundwater (Wells) Systems 1971-82

Illness	Outbreaks	Cases
1. Untreated Well Water		
A. Gastroenteritis	69	6,775
B. Chemical Poisoning	12	157
C. Shigellosis	10	995
D. Hepatitis A	8	181
E. Viral Gastroenteritis	3	338
F. Giardiasis	3	23
G. Typhoid Fever	3	12
H. Salmonellosis	1	61
I. Yersiniosis	1	16
Subtotal	110	8,558
2. Inadequate or Interrupted Disinfection of Well Water		
A. Gastroenteritis	49	16,429
B. Shigellosis	8	3,885
C. Viral Gastroenteritis	3	525
D. Salmonellosis	3	291
E. Hepatitis A	3	148
F. Typhoid Fever	1	210
Subtotal	67	21,488
Totals	177	30,046

TABLE 10

Waterborne Outbreaks Caused by Use of Contaminated, Untreated Water and Inadequate Treatment 1971-82

Cause of Outbreak	Outbreaks	Illnesses
1. Contamination of untreated surface water	31	1,676
2. Contamination of untreated spring water	15	1,268
3. Contamination of untreated wells water	110	8,558
Subtotal	156	11,502
4. Inadequate or interrupted disinfection when only treatment		
A. Surface water systems	57	22,961
B. Well water systems	67	21,488
C. Spring water systems	12	3,023
Subtotal	136	47,472
5. Disinfection with other treatment		
A. Inadequate or interrupted disinfection of surface water	2	67
B. Inadequate control of filtration/pretreatment of surface water	6	7,055
C. Inadequate control of chemical feed for surface and groundwaters	10	731
Subtotal	18	7,853
Totals	310	66,827

TABLE 11

Waterborne Outbreaks Caused by Distribution Deficiencies
1971-82

Cause of Outbreak	Outbreaks	Illnesses
1. Distribution Piping and Plumbing		
A. Cross-connection	21	5,728
B. Backsiphonage	13	1,428
C. Contamination or corrosion of household plumbing or service lines	6	56
D. Contamination of broken, leaking mains	2	65
E. Contamination of water mains during construction or repair	5	1,710
F. Corrosion due to CO_2 from soft drink machine	5	172
Subtotal	52	9,159
2. Storage Facilities		
A. Contamination of distribution storage	7	6,034
B. Contamination of cistern or private storage tank	4	336
Subtotal	11	6,370
Totals	63	15,529

TABLE 12

Waterborne Outbreaks Caused by Miscellaneous Deficiencies
1971-82

Cause of Outbreak	Outbreaks	Illnesses
Use of water not intended for drinking	6	69
Contaminated ice	3	41
Contaminated bottled water	2	5
Deliberate contamination	2	2,008
Contaminated drinking fountain	1	6
Ingestion while swimming	3	139
Insufficient data	9	1,426
Total	26	3,694

FIGURE 1

Seasonal Distribution Of Waterborne Outbreaks In Untreated Groundwater Systems

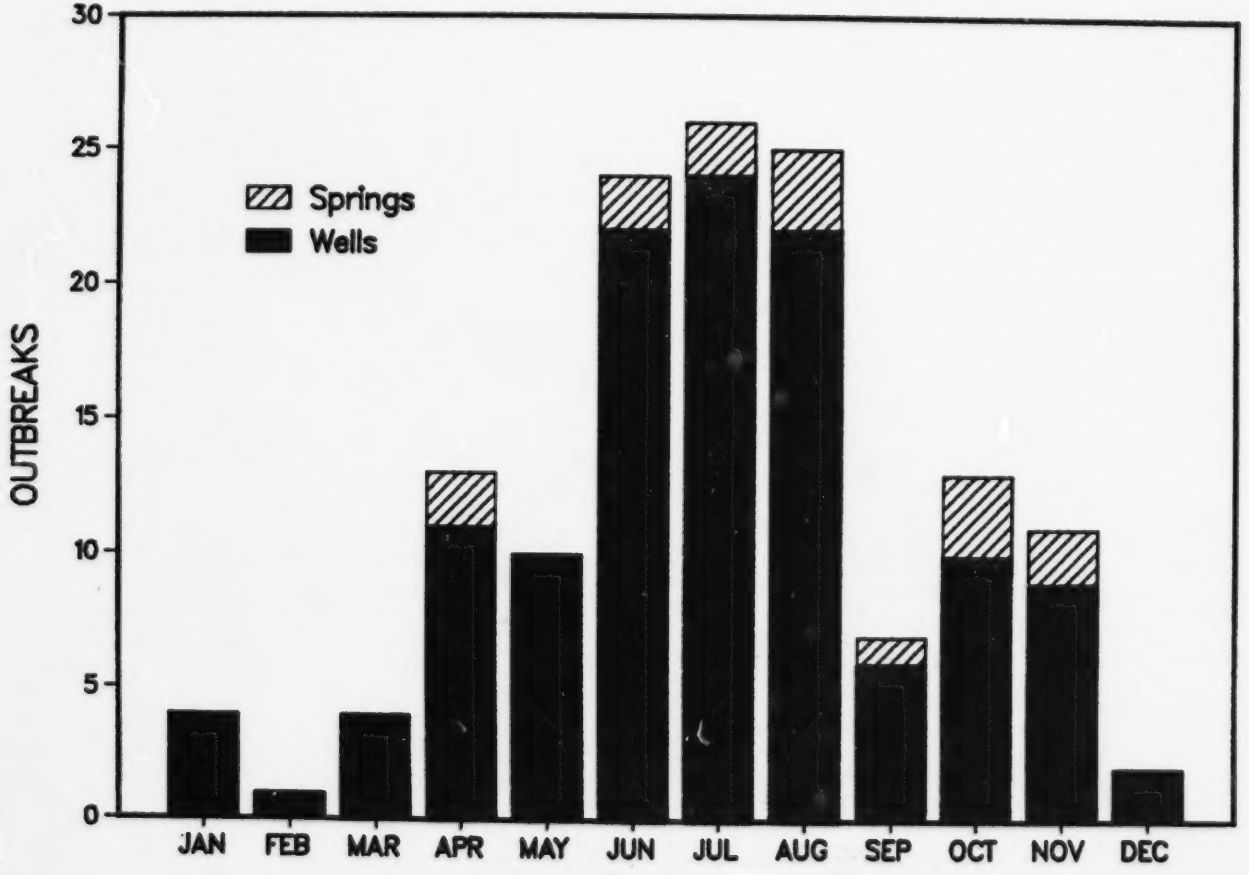
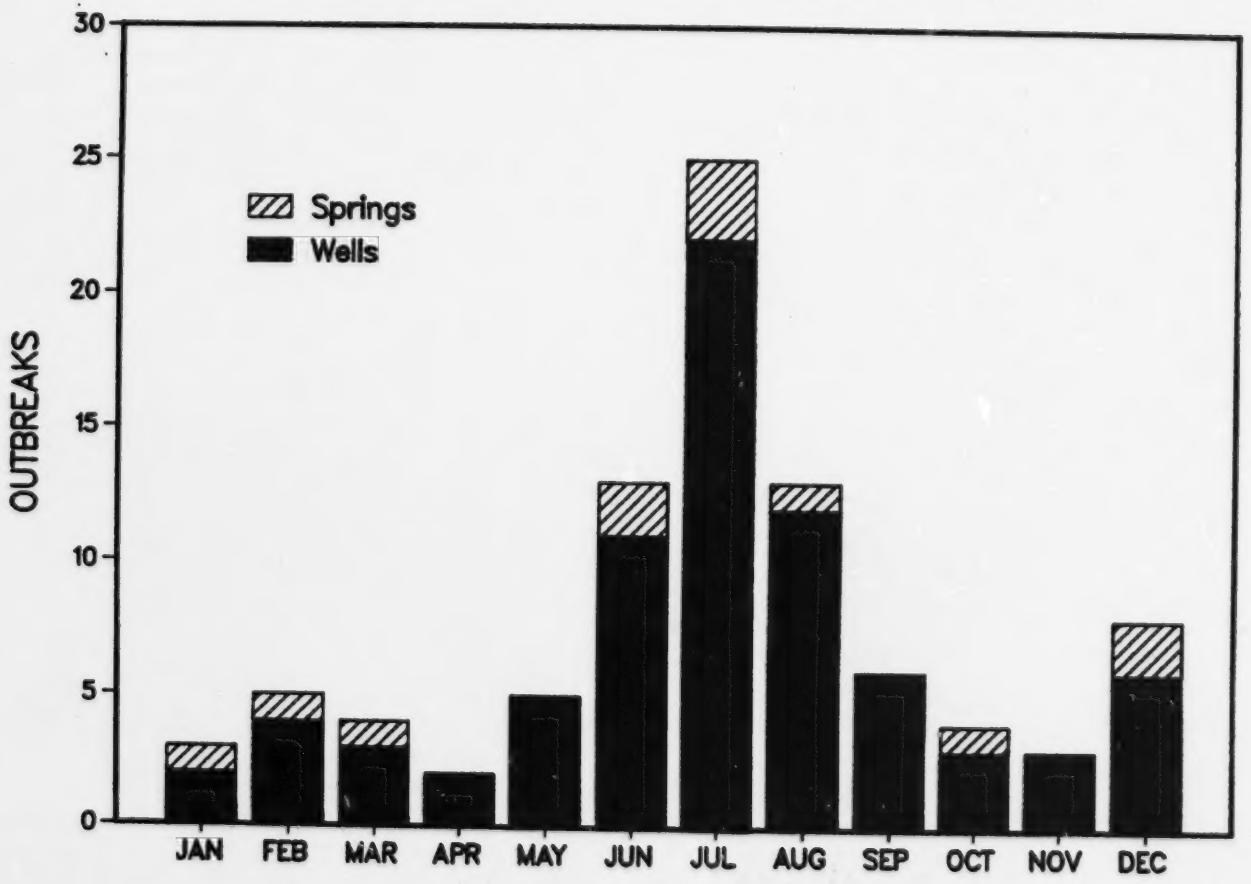


FIGURE 2

Seasonal Distribution Of Waterborne Outbreaks In Inadaquately Disinfected Groundwater Systems

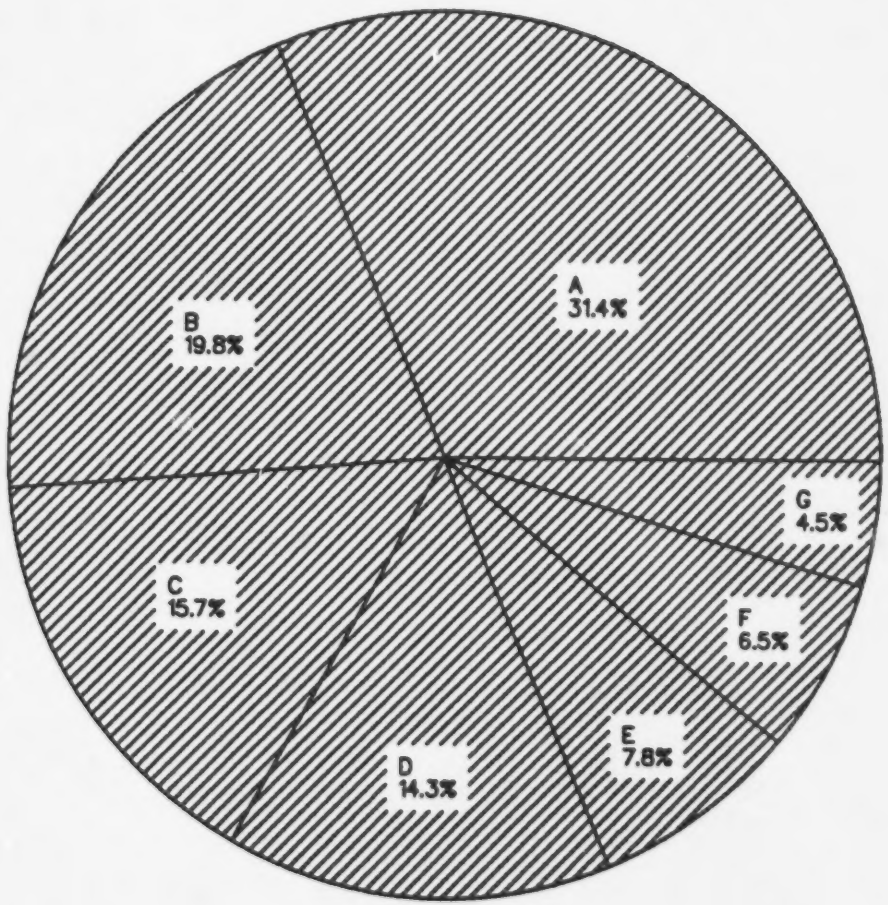


LEGEND FOR FIGURE 3

A. Use of contaminated, untreated groundwater
B. Inadequate or interrupted disinfection of groundwater
C. Distribution system deficiencies
D. Inadequate or interrupted disinfection of surface water
E. Use of contaminated, untreated surface water
F. Miscellaneous deficiencies
G. Inadequate filtration, pretreatment, chemical feed

FIGURE 3

Causes Of Waterborne Outbreaks 1971–1982



LEGEND FOR FIGURE 4

A. Use of contaminated, untreated groundwater
B. Inadequate or interrupted disinfection of groundwater
C. Distribution system deficiencies
D. Inadequate or interrupted disinfection of surface water
E. Use of contaminated, untreated surface water
F. Miscellaneous deficiencies
G. Inadequate filtration, pretreatment, chemical feed

FIGURE 4

Causes Of Waterborne Illness 1971–1982